Sedimentation and contaminant loading: effects on eelgrass (*Zostera marina*) bed health in northern Puget Sound

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Extended abstract

Zostera marina beds are becoming increasingly fragmented in northern Puget Sound, or have disappeared altogether at sites where healthy meadows once flourished. Eelgrass is known to be sensitive to changes in temperature, nutrient enrichments, contaminants, sediment redox conditions, and turbidity, which is related to sedimentation. However, the reasons for recent eelgrass die-offs and disappearances are not yet understood. The primary goal of this study was to investigate relationships between eelgrass distributions, sedimentation, and sedimentary metal concentrations.

Surface grab samples and long sediment cores were collected in the San Juan Islands (Westcott Bay, Blind Bay, and Picnic Cove), Padilla Bay, and Skagit Bay during August 31-September 10, 2004. Samples were analyzed for grain size, sediment chemistry, and lipids. Sediment chemistry was determined on the fine fraction (< 63 μm). Approximately 20 mg of sediment was digested according to EPA Method 3052 using concentrated nitric and hydrofluoric acid. Major (Na, Mg, Al, P, K, Ca, Fe), minor (Mn, Sr, Ba), and trace (Li, V, Cr, Co, Ni, Cu, Zn, As, Mo, Cd, Pb, Th, U) elements were measured by inductively coupled plasma mass spectrometry. Absolute concentrations were calculated relative to USGS rock standards and NIST sediment reference materials (SRM 1646a, SRM 2702). Analytical uncertainties for all elements were less than 5%.

Concentrations of most metals were near natural background levels in surface sediments throughout Westcott, Blind, Padilla, and Skagit bays. In Westcott and Blind bays, sites with eelgrass had significantly lower concentrations of molybdenum (1.5 ± 0.3 ppm), a redox-sensitive element, than sites where eelgrass was absent (2.6 ± 0.2 ppm). This pattern was generally true for cadmium and copper as well. The sites where eelgrass was present were dominated by medium and fine sands (55% to 96% by weight) while the sites were eelgrass was absent were dominated by fine sediments (silts+clays, 86% and 97%). One deviation from this trend occurred at a site in Westcott Bay dominated by medium and fine sands that did not have eelgrass. This site, near the outlet of a seasonal creek, had Cd concentrations 5 times higher (2 ppm) than background levels, the highest concentration observed in northern Puget Sound during this study. It is interesting to note that the Westcott Bay surface sediments had the highest average Cd concentrations of the three sites, 1.5 ± 0.4 ppm (1σ, n=6).

In Padilla Bay, eelgrass was healthiest in the northeastern portion of the bay, which was dominated by fine sands (80% by weight). Eelgrass was absent from sites in south Padilla Bay which were dominated by fine sediments (67% by weight). Most sedimentary metal concentrations were near natural background levels, and there did not appear to be relationships between sedimentary metal concentrations and eelgrass in Padilla Bay. Copper and nickel concentrations were 43% and 28% higher, respectively, in the sediments of Skagit Bay than in neighboring Padilla Bay, and could have been related to agricultural chemicals used in the Skagit Valley.

A 2 m-long sediment core from south Padilla Bay allowed natural background levels to be defined for 22 elements. Although the 2 m-long core had not been ^{210}Pb-dated at the time of this presentation, rough chronologic control was provided by the core stratigraphy. The bottom 30 cm of the core was composed of gravel and very coarse sand, which transitioned to 80 cm of organic-rich silt within a few centimeters. Such a dramatic facies change probably reflected the diversion of the Skagit River in the late 1800's to its present position south of Padilla Bay. Most metal concentrations were relatively uniform and near background levels throughout the upper 60 cm of the Padilla Bay sediment column. It should be noted that the upper portion of the 2-m long sediment core had not been analyzed at the time of this presentation, so vertical metal profiles in the upper 60 cm were obtained from cores collected on the east side of Padilla Bay off Joe Leary Slough and on the west side of Padilla Bay at March Point. Only As, Cd, Mo, Th, U were enriched above background levels in recent sediments at March Point. Cu, Zn, and Pb showed a sharp peak 8-9 cm below the sediment surface at March Point.

Preliminary results from a sedimentary eelgrass proxy based on organic biomarkers and their carbon isotope ratios ($\delta^{13}C$) showed promise. The n-alkane fraction in eelgrass leaves from Westcott Bay showed a distinctive odd-over-even preference (C_{15}-C_{17}-C_{19}) and had $\delta^{13}C$ values ranging from –17‰ to –23‰, unusually high values for a C3 plant. In the sediments, the n-alkane odd-over-even preference was still observed, however relative abundances of the n-alkanes differed. Furthermore, the $\delta^{13}C$ value of n-alkanes in the sediment was –26‰, similar to that of terrestrial plant matter. Future work will explore whether altered biomarker/isotopic signals in the sediments were due to the presence of terrestrial plant detritus, degradation of the biomarkers, or differences in the compositions of eelgrass leaves relative to rhizomes and roots. Utilizing a suite of biomarkers, including sterols, fatty acids, and lignin-phenols, as well as compound-specific $\delta^{13}C$ values, will help pinpoint the sedimentary eelgrass signature.

In conclusion, we found a consistent relationship between the presence of eelgrass and sand-dominated sediments in northern Puget Sound. Most sedimentary metals were near natural background levels and were not related to eelgrass distributions. Low concentrations of redox-sensitive elements Mo and Cd at sites in Westcott and Blind Bays where eelgrass was present may suggest that, in addition to grain size, reducing sediments could have influenced eelgrass distributions in the San Juan Islands.